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Department of Pesticide Regulation

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MEMORANDUM

TO: Douglas Y. Okumura, Chief
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DATE: September 8, 1998

SUBJECT: MONITORING RESULTS FROM VIRTUALLY IMPERMEABLE FILM AND HIGH DENSITY POLYETHYLENE (HIGH BARRIER) TARPED, SHALLOW INJECTION METHYL BROMIDE APPLICATION IN ORANGE COUNTY

Introduction—Methyl bromide is widely used as a preplant soil fumigant for control of nematodes, fungi, diseases, and weeds. The Department of Pesticide Regulation (DPR) and county agricultural commissioners have implemented permit conditions, including buffer zones, to mitigate unacceptable methyl bromide exposure. Buffer zones are set so that concentrations measured at this distance do not exceed 0.21 parts per million (ppm) (24-hour time-weighted average [TWA]). Laboratory studies have shown the Virtually Impermeable Film (VIF) less permeable to methyl bromide compared to high density polyethylene (high barrier) films (Tri Cal 1997), although the two films showed similar off-site air concentrations during DPR monitoring (Kim & Segawa 1998). Other factors may be dominating the methyl bromide flux from fumigated fields including, environmental, soil properties, or leakage from edges and seams.

Eight one-acre plots within one large field were fumigated, four using the VIF and four the high barrier tarpaulin, thus minimizing variations in soil properties and weather between plots. Reducing leakage around the edges of the field was also investigated by extending the tarpaulin's edge. An extra panel width (approximately 11 feet) with no methyl bromide injected was added to all four edges of two plots of each type of film. All monitoring was performed 30 feet from the edge of the injected area.

Materials and Methods—The treated area consisted of eight 210 feet x 210 feet (1-acre) plots in a 1,200 feet x 2,400 feet field. The plots were lined up in two groups of four, labeled A-D and E-H (Figure 1). An untreated buffer, measuring 400 feet, was provided between adjacent plots, and 500 feet between the two groups. The VIF tarpaulin was used on plots B, D, F, and H, the high barrier on A, C, E, and G. The field was located in East Irvine, Orange County.

The plots were treated with methyl bromide by a shallow broadcast tarped application method. The methyl bromide was injected into the soil at a depth of 12 inches and immediately covered with either the VIF or high barrier tarpaulin with the application rig. The plots were treated in 11-foot wide strips, as the treatment progressed, one edge of the tarpaulin glued to the preceding strip the other edge buried in the soil.

The nominal application rate was 350 pounds per acre of formulated product, 67 percent methyl bromide, and 33 percent chloropicrin. The actual application rate was from 328 to 355 pounds per one-acre plot (Figure 1). Two application rigs were used, one for each type of tarpaulin. Non-treated edge panels (no methyl bromide or chloropicrin injected) were added to plots B, C, F, and G, figure 1. The application took place on two days, plots A-D on June 5, 1998, and plots E-H on June 7, 1998. Each individual application took 55 to 90 minutes to complete; and the entire application to four plots lasted three hours. Tarpaulin cutting was performed five days after application, and was removed the following day.

Ambient air samples were collected at eight locations around each plot, using charcoal tubes and SKC model XR8 air samplers with low flow adapters, or SKC model 222 low flow personal samplers. The flow rate for the XR8 samplers calibrated at 14.5 to 15.6 ml/min and 17 to 22 ml/min for the model 222 samplers. All samplers were calibrated prior to the first sampling period and checked after the last period.

Samples were collected for two 6-hour, followed by three 12-hour periods beginning with the start of application. No samples were collected on days 3, 4, and 5. On day 6 the tarpaulin was cut— and then removed on the following day, samples were collected for two 6-hour, followed by one 12-hour period on each day. A total of 96 hours of monitoring was performed, 48, 24, and 24 hours for application, cutting and removal respectively. Samplers were located at approximately 30 feet from the treatment edge. Tables 1 - 4, and Figure 1 indicate the position of each sampler. Some samplers were repositioned to 30 feet after the application monitoring, the first five sampling intervals, if the original placement edge was inaccurate.

The prevailing wind direction was from the southwest, figure 2 shows 24-hour wind rose diagrams corresponding to the first three sampling intervals after the application to the plots. Temperatures ranged from 51 to 72 degrees Fahrenheit. The weather was generally overcast in the mornings, clearing in the afternoons, with light rain during sampling period 6, and light drizzle during sample period 4 for plots E - H, and a light drizzle during period 9 for plots A - D.

Analysis of variance was used to test the effect of the treatments. A two-factor design was employed using tarp type (VIF vs high barrier), and edging (edging or no edging) as factors. The variable analyzed was the maximum 24-hour concentration from periods 1 - 3 for each plot.

Results—Generally, the highest period concentrations occurred during the second period for both groups of plots. The highest second period concentration (6- hour) occurred in plot D at 0.142 ppm. The highest 24-hour TWA were based on intervals 1 - 3 for both groups of plots. The highest TWA was 0.072 ppm in plot D, which received the VIF only treatment.

There were also significant concentrations during tarp removal. The highest period concentration over the study occurred in plot F, at site 4, during the first 6-hour interval of tarp cutting and was 0.170 ppm. Similarly, 0.137 ppm was measured in plot E during tarp cutting. Concentrations, however, declined markedly during the tarp removal period.

The statistical analysis indicated no significant effect of either treatment factor on the maximum plot 24-hour TWA (Table 5). The mean maximum 24-hour concentrations varied randomly around 0.059 ppm for the various treatment combinations (Table 6).

The distinctly similar results obtained between VIF and high barrier tarps is perhaps explained by permeability tests which were performed on tarp samples from a previous application (Duafala 1998). Eight VIF samples were analyzed. Permeability amongst three of those samples were 9.7, 24.4, and 35.4 MBF compared to 3.9 and 5.3 MBF for high-barrier tarp. The other 5 samples for VIF were all below 0.95 MBF. As Duafala (1998) states that there is probably ". . . a quality control problem with the manufacturing of this film."

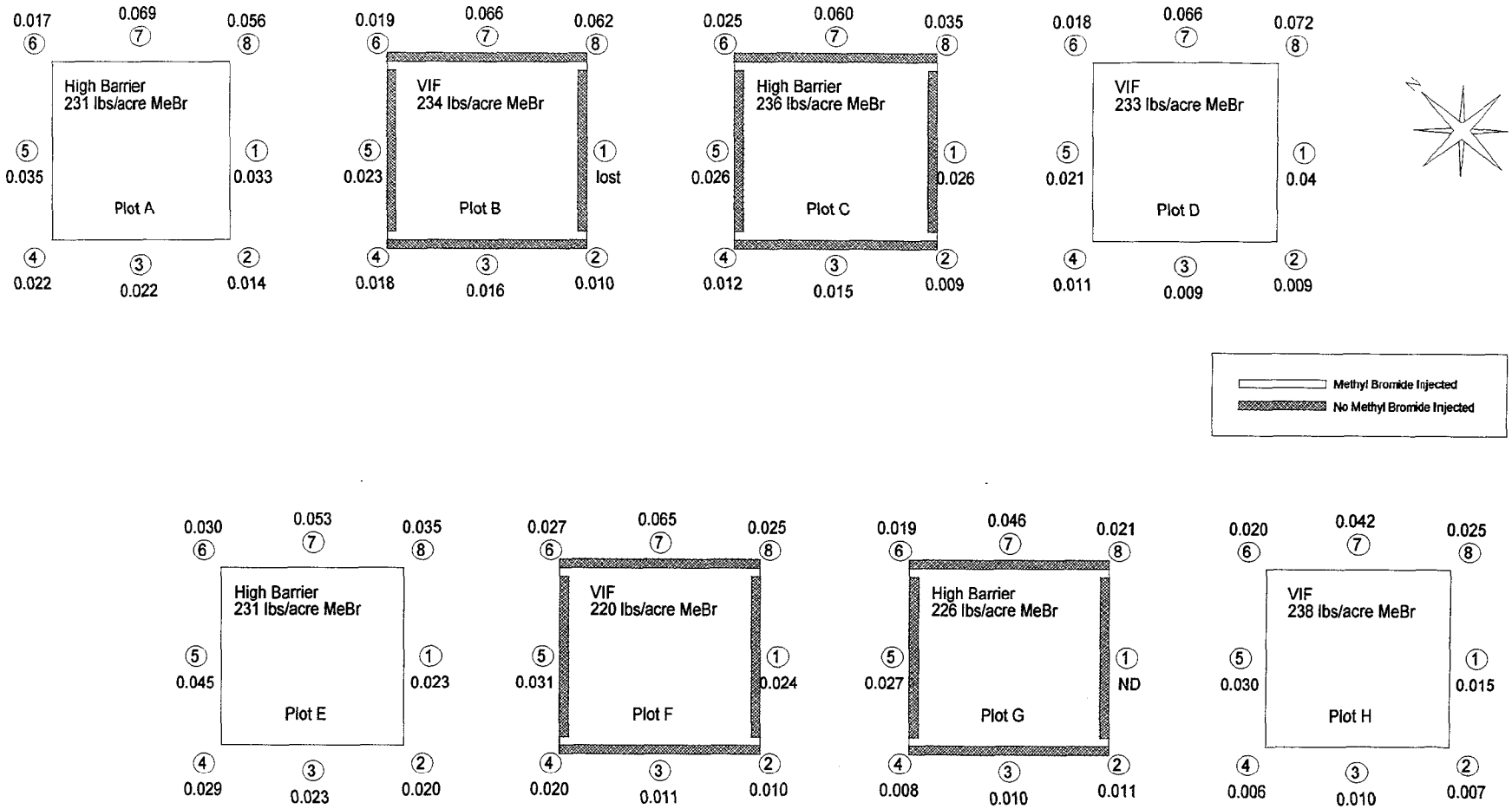
Attachment

Duafala, Tom. 1998. Letter to James W. Wells regarding measurements of tarp permeability of impermeable film dated July 2, 1998.

Kim, K. David and Randy Segawa, MONITORING RESULTS FROM A TARPED, VIRTUALLY IMPERMEABLE FILM, SHALLOW INJECTION METHYL BROMIDE APPLICATION IN ORANGE COUNTY, Memorandum to Douglas Y. Okumura, Chief, Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento California. August 5, 1998.

TRICAL Research and Bolsa Research, COMPARISON OF FLUX RATE BETWEEN DOW HBF AND EU2 FILMS, DRAFT REPORT #3. October 30, 1997.

Figure 1. The application site (not to scale) and the 24-hour average concentration* for intervals 1,2 & 3 (parts per million).



* Includes periods of no detectable amount, ½ the detection limit was used to obtain the 24 -hour average.
lost = Sample lost due to sampler malfunction or laboratory error.

Figure 2. The application site, scale drawing, and windrose diagrams for sampling periods represented in fig. #1

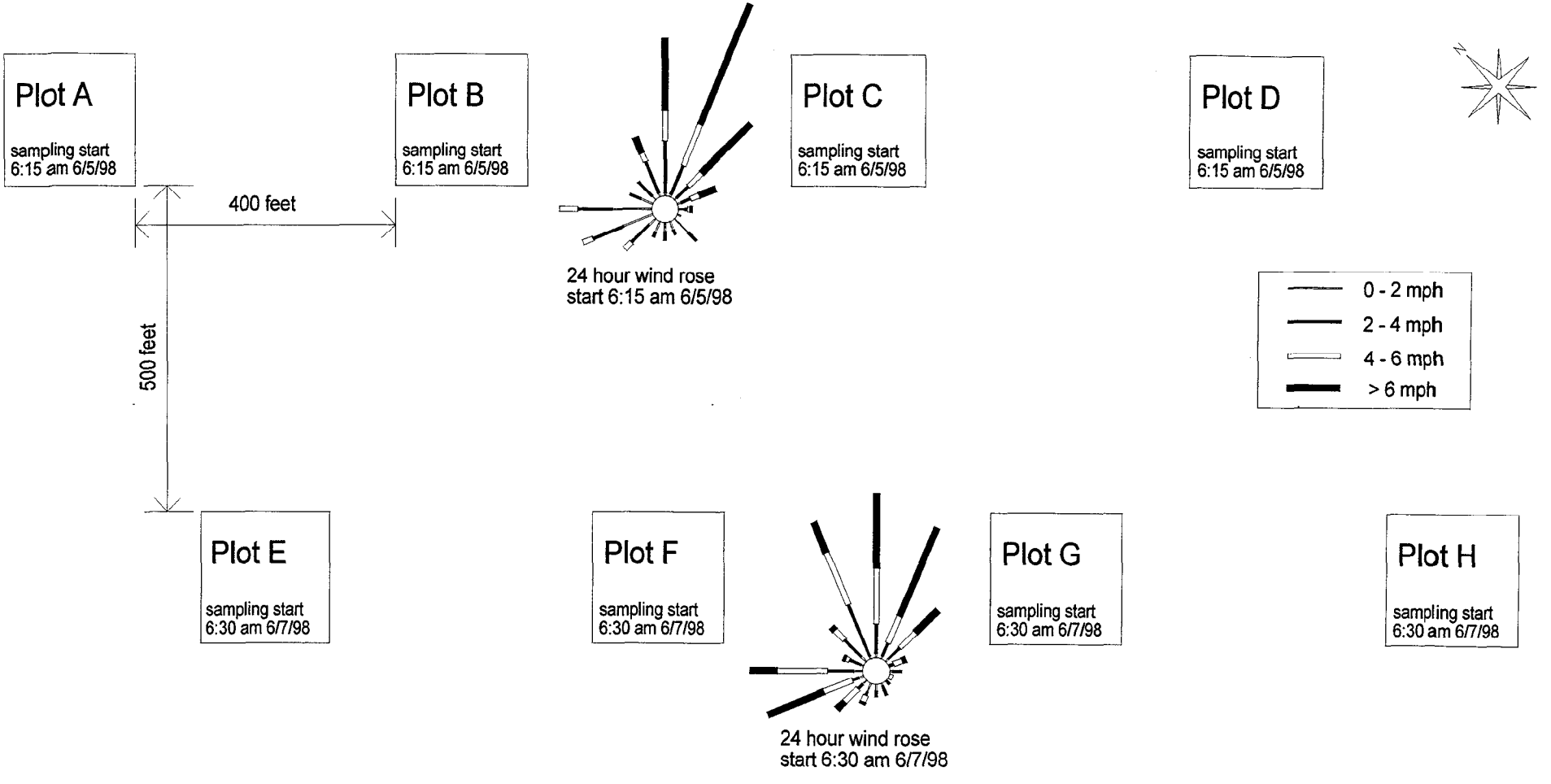


Table 1. Application ambient methyl bromide air concentrations, plots A - D, 6/5- 6/7/98

Sampler			Methyl Bromide (ppm) for each Sampling Period					
			Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	24-Hour
Plot	Site	Distance	6 Hour	6 Hour	12 Hour	12 Hour	12 Hour	TWA [1]
A	1	27 ft	**0.037**	**0.045**	**0.025**	0.012	0.018	0.033
High	2	32 ft	**0.012**	**ND**	**0.019**	0.007	0.007	0.014*
Barrier	3	31 ft	**0.009**	**ND**	**0.037**	0.012	0.011	0.022*
	4	36 ft	**ND**	**ND**	**0.038**	0.005	0.011	0.022*
	5	35 ft	**0.013**	**ND**	**0.061**	0.013	0.009	0.035*
	6	36 ft	**0.012**	**ND**	**0.026**	0.012	ND	0.017*
	7	32 ft	**0.060**	**0.092**	**0.062**	0.032	0.034	0.069
	8	29 ft	**0.058**	**0.094**	**0.035**	0.020	0.038	0.056
B	1	27 ft	**0.043**	**0.048**	**lost**	0.010	0.013	lost
VIF	2	30 ft	**ND**	**ND**	**0.016**	0.005	0.007	0.010*
	3	30 ft	**ND**	**ND**	**0.027**	0.009	0.008	0.016*
Edge	4	34 ft	**ND**	**ND**	**0.031**	0.006	0.014	0.018*
Panels	5	36 ft	**ND**	**ND**	**0.042**	0.013	0.015	0.023*
	6	37 ft	**0.020**	**ND**	**0.026**	0.012	0.013	0.019*
	7	29 ft	**0.064**	**0.107**	**0.047**	0.028	0.031	0.066
	8	30 ft	**0.077**	**0.111**	**0.030**	0.011	0.032	0.062
C	1	29 ft	**0.033**	**0.042**	**0.015**	0.008	0.018	0.026
High	2	31 ft	**ND**	**ND**	**0.014**	0.005	0.006	0.009*
Barrier	3	30 ft	**ND**	**ND**	**0.026**	0.011	0.007	0.015*
	4	35 ft	**ND**	**ND**	**0.019**	0.006	lost	0.012*
Edge	5	37 ft	**ND**	**ND**	**0.047**	0.011	0.020	0.026*
Panels	6	31 ft	**0.011**	**ND**	**0.042**	0.014	lost	0.025*
	7	30 ft	**0.039**	**0.076**	**0.062**	0.032	0.024	0.060
	8	30 ft	**0.037**	**0.063**	**0.021**	0.016	0.032	0.035
D	1	31 ft	**0.079**	**0.046**	**0.017**	0.014	0.016	0.040
VIF	2	29 ft	**0.014**	**ND**	**0.007**	0.005	0.006	0.009*
	3	29 ft	**0.012**	**ND**	**0.010**	0.008	0.005	0.009*
	4	26 ft	**ND**	**ND**	**0.017**	0.005	0.008	0.011*
	5	25 ft	**0.018**	**ND**	**0.031**	0.015	0.010	0.021*
	6	28 ft	**0.019**	**0.011**	**0.021**	0.014	0.009	0.018
	7	30 ft	**0.064**	**0.107**	**0.047**	0.035	0.024	0.066
	8	28 ft	**0.099**	**0.142**	**0.024**	0.025	0.037	0.072

[1] the peak 24-hour time-weighted average is derived from the concentrations in bold.

* indicates that the 24-hour average includes a period of no detectable amount, 0.0025ppm (12-hr sample) or 0.005ppm (6-hr sample) was used to obtain the 24-hour average. ND = No detectable amount; reporting limit = 0.007 to 0.010 ppm for 6-hr samples and 0.003 to 0.006 ppm for 12-hr samples. Reporting limit varied depending on volume of air sampled. lost = Sample lost due to sampler malfunction or laboratory error.

Table 2 Application ambient methyl bromide air concentrations, plots E-F, 6/7 - 6/9/98

Sampler			Methyl Bromide (ppm) for each Sampling Period					
			Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	24-Hour
Plot	Site	Distance	6 Hour	6 Hour	12 Hour	12 Hour	12 Hour	TWA [1]
E	1	29 ft	**0.036**	**0.016**	**0.020**	0.011	0.010	0.023
High	2	31 ft	**0.027**	**ND**	**0.023**	0.005	0.014	0.020*
Barrier	3	29 ft	**0.025**	**ND**	**0.031**	0.016	lost	0.023*
	4	33 ft	**0.016**	**ND**	**0.048**	0.025	0.041	0.029*
	5	35 ft	**0.015**	**0.010**	**0.078**	0.040	0.067	0.045
	6	31 ft	**0.019**	**0.026**	**0.037**	0.027	0.020	0.030
	7	29 ft	**0.036**	**0.082**	**0.047**	0.035	0.017	0.053
	8	28 ft	**0.040**	**0.054**	**0.022**	0.019	0.009	0.035
F	1	28 ft	**0.033**	**0.019**	**0.022**	ND	0.014	0.024
VIF	2	31 ft	**0.011**	**ND**	**0.012**	0.005	0.012	0.010*
	3	30 ft	**0.011**	**ND**	**0.014**	0.007	0.011	0.011*
Edge	4	27 ft	**ND**	**ND**	**0.035**	0.016	0.027	0.020*
Panels	5	27 ft	**0.012**	**0.011**	**0.051**	0.031	0.044	0.031
	6	30 ft	**0.011**	**0.028**	**0.034**	0.033	0.023	0.027
	7	31 ft	**0.043**	**0.128**	**0.045**	0.043	0.016	0.065
	8	30 ft	**0.025**	**0.048**	**0.014**	0.010	0.008	0.025
G	1	30 ft	**ND**	**ND**	**ND**	ND	ND	ND
High	2	30 ft	**0.013**	**ND**	**0.012**	0.004	0.007	0.011*
Barrier	3	30 ft	**0.009**	**ND**	**0.013**	0.009	0.009	0.010*
	4	35 ft	**ND**	**ND**	**0.011**	0.013	0.018	0.008*
Edge	5	36 ft	**0.009**	**0.010**	**0.044**	0.027	0.045	0.027
Panels	6	33 ft	**0.011**	**0.010**	**0.027**	0.022	0.021	0.019
	7	31 ft	**0.027**	**0.078**	**0.041**	0.009	0.010	0.046
	8	29 ft	**0.017**	**0.043**	**0.012**	ND	0.004	0.021
H	1	28 ft	**0.038**	**0.018**	**ND**	ND	ND	0.015*
VIF	2	29 ft	**0.018**	**ND**	**ND**	ND	ND	0.007*
	3	30 ft	**0.015**	**ND**	**0.009**	0.006	0.004	0.010*
	4	27 ft	**ND**	**ND**	**0.007**	0.012	0.015	0.006*
	5	26 ft	**0.010**	**ND**	**0.053**	0.026	0.030	0.030*
	6	29 ft	**0.017**	**0.017**	**0.023**	0.031	0.015	0.020
	7	32 ft	**0.033**	**0.070**	**0.033**	0.034	0.007	0.042
	8	29 ft	**0.023**	**0.053**	**0.011**	0.007	ND	0.025

[1] the peak 24-hour time-weighted average is derived from the concentrations in bold.

* indicates that the 24-hour average includes a period of no detectable amount, 0.0025 ppm (12-hr sample) or 0.005 ppm (6-hr sample) was used to obtain the 24-hour average. ND = No detectable amount; reporting limit = 0.007 to 0.010 ppm for 6-hr samples and 0.003 to 0.006 ppm for 12-hr samples. Reporting limit varied depending on volume of air sampled. lost = Sample lost due to sampler malfunction or laboratory error.

Table 3. Tarpaulin cutting and removal ambient methyl bromide air concentrations, plots A- D, 6/10 - 6/12/98.

			Methyl Bromide (ppm) for each Sampling Period						
			Cut Tarpaulin			Remove Tarpaulin			
Sampler			Interval 6	Int. 7	Int. 8	Int. 9	Int. 10	Int. 11	24-Hour
Plot	Site	Distance	6 Hour	6 Hour	12 Hour	6 Hour	6 Hour	12 Hour	TWA [1]
A	1	27 ft	**0.027**	**0.014**	**ND**	ND	ND	ND	0.012*
High	2	32 ft	**ND**	**ND**	**ND**	ND	ND	ND	ND
Barrier	3	31 ft	**ND**	**ND**	**ND**	ND	ND	ND	ND
	4	30 ft	**ND**	**ND**	**ND**	ND	ND	0.006	ND
	5	30 ft	**0.026**	**ND**	**0.019**	0.018	ND	0.011	0.017*
	6	30 ft	**0.020**	**ND**	**0.023**	0.012	ND	0.009	0.017*
	7	32 ft	**0.057**	**0.039**	**0.017**	ND	ND	0.013	0.032
	8	29 ft	**0.045**	**0.031**	**ND**	ND	ND	ND	0.020*
B	1	27 ft	**0.032**	**0.012**	**ND**	ND	ND	ND	0.012*
VIF	2	30 ft	**ND**	**ND**	**ND**	ND	ND	0.005	ND
	3	30 ft	**ND**	**ND**	**ND**	ND	ND	ND	ND
Edge	4	30 ft	**ND**	**ND**	**0.007**	ND	ND	0.006	0.006*
Panels	5	30 ft	**0.014**	**ND**	**0.014**	0.012	ND	0.007	0.012*
	6	29 ft	**0.024**	**ND**	**0.020**	ND	ND	0.012	0.017*
	7	29 ft	**0.038**	**ND**	**0.014**	ND	0.012	0.010	0.018*
	8	30 ft	**0.044**	**0.024**	**ND**	ND	ND	ND	0.018*
C	1	29 ft	**0.058**	**0.017**	**ND**	ND	ND	ND	0.020*
High	2	31 ft	**ND**	**ND**	**ND**	ND	ND	ND	ND
Barrier	3	30 ft	**ND**	**ND**	**ND**	ND	ND	ND	ND
	4	30 ft	**ND**	**ND**	**0.008**	ND	ND	ND	0.006*
Edge	5	30 ft	**0.011**	**ND**	**0.017**	0.015	ND	0.007	0.013*
Panels	6	31 ft	**0.027**	**ND**	**0.021**	0.009	ND	0.007	0.019*
	7	30 ft	**0.063**	**0.027**	**0.015**	ND	0.013	0.009	0.030
	8	30 ft	**0.071**	**0.029**	**ND**	ND	ND	ND	0.026*
D	1	31 ft	**0.048**	**0.012**	**ND**	ND	ND	ND	0.016*
VIF	2	29 ft	**0.007**	**ND**	**ND**	ND	ND	ND	0.004*
	3	29 ft	**ND**	**ND**	**ND**	ND	ND	ND	ND
	4	26 ft	**ND**	**ND**	**0.009**	ND	ND	ND	0.007*
	5	25 ft	**ND**	**ND**	**0.016**	0.007	ND	0.003	0.010*
	6	28 ft	**0.007**	**ND**	**0.013**	ND	ND	ND	0.010*
	7	30 ft	**0.035**	**0.016**	**0.013**	ND	0.010	0.005	0.019
	8	28 ft	**0.056**	**0.025**	**ND**	ND	ND	ND	0.021*

[1] the peak 24-hour time-weighted average is derived from the concentrations in bold.

* indicates that the 24-hour average includes a period of no detectable amount, 0.0025ppm (12-hr sample) or 0.005ppm (6-hr sample) was used to obtain the 24-hour average.

ND = No detectable amount; reporting limit = 0.007 to 0.010 ppm for 6-hr samples and 0.003 to 0.006 ppm for 12-hr samples. Reporting limit varied depending on volume of air sampled.

lost = Sample lost due to sampler malfunction or laboratory error.

Table 4. Tarpaulin cutting and removal ambient methyl bromide air concentrations, plots E - F, 6/12 - 6/14/1998.

			Methyl Bromide (ppm) for each Sampling Period						
			Cut Tarpaulin			Remove Tarpaulin			
Sampler			Interval 6	Int. 7	Int. 8	Int. 9	Int. 10	Int. 11	24 Hour[1]
Plot	Site	Distance	6 Hour	6 Hour	12 Hour	6 Hour	6 Hour	12 Hour	TWA
E	1	29 ft	**0.018**	**ND**	**0.010**	0.012	ND	ND	0.011*
High	2	31 ft	**0.042**	**ND**	**0.018**	ND	ND	0.015	0.021*
Barrier	3	29 ft	**0.035**	**lost**	**0.014**	ND	ND	0.012	0.021[2]
	4	30 ft	**lost**	**ND**	**0.023**	ND	ND	0.014	0.017[2*]
	5	30 ft	**0.137**	**0.018**	**0.037**	ND	ND	0.014	0.057
	6	31 ft	**0.017**	**0.019***	**0.017**	ND	ND	0.009	0.017[3]
	7	29 ft	**0.011**	**0.034**	**0.016**	ND	ND	0.010	0.019
	8	28 ft	**ND**	**ND**	**0.012**	ND	ND	ND	0.008*
F	1	28 ft	**0.024**	**ND**	**0.010**	0.016	ND	0.006	0.012*
VIF	2	31 ft	**0.038**	**ND**	**0.014**	ND	ND	0.008	0.018*
	3	30 ft	**0.043**	**ND**	**0.016**	ND	ND	0.014	0.020*
Edge	4	30 ft	**0.170**	**ND**	**0.019**	ND	ND	0.016	0.054*
Panels	5	30 ft	**0.103**	**0.024**	**0.032**	ND	ND	0.014	0.048
	6	30 ft	**0.013**	**0.025**	**0.014**	ND	ND	0.006	0.016
	7	31 ft	**0.011**	**0.027**	**0.014**	ND	ND	0.009	0.017
	8	30 ft	**ND**	**ND**	**0.010**	ND	ND	0.006	0.008*
G	1	30 ft	**0.012**	**ND**	**0.006**	0.009	ND	ND	0.007*
High	2	30 ft	**0.018**	**ND**	**0.008**	ND	ND	0.004	0.009*
Barrier	3	30 ft	**0.069**	**ND**	**0.012**	ND	ND	0.006	0.024*
	4	30 ft	**0.082**	**ND**	**0.022**	ND	ND	0.014	0.033*
Edge	5	30 ft	**0.067**	**0.015**	**0.022**	ND	ND	0.011	0.032
Panels	6	30 ft	**ND**	**ND**	**0.007**	ND	ND	ND	0.006*
	7	31 ft	**ND**	**0.031**	**0.012**	ND	ND	0.007	0.015*
	8	29 ft	**ND**	**ND**	**0.008**	ND	ND	ND	0.007*
H	1	28 ft	**ND**	**ND**	**ND**	0.009	ND	ND	ND
VIF	2	29 ft	**ND**	**ND**	**ND**	ND	ND	ND	ND
	3	30 ft	**0.009**	**ND**	**0.005**	ND	ND	0.008	0.006*
	4	30 ft	**0.054**	**ND**	**0.015**	ND	ND	0.013	0.022*
	5	30 ft	**0.067**	**0.016**	**0.016**	ND	ND	0.012	0.029
	6	31 ft	**ND**	**70.016**	**ND**	ND	ND	0.004	0.007*
	7	32 ft	**ND**	**0.016**	**ND**	ND	ND	ND	0.006*
	8	29 ft	**ND**	**ND**	**ND**	ND	ND	ND	ND

[1] the peak 24-hour time-weighted average is derived from the concentrations in bold.

[2] due to lost samples, a 18-hour time-weighted average is reported.

* indicates that the 24-hour average includes a period of no detectable amount, 0.0025ppm (12-hr sample) or 0.005ppm (6-hr sample) was used to obtain the 24-hour average.

ND = No detectable amount; reporting limit = 0.007 to 0.010 ppm for 6-hr samples and 0.003 to 0.006 ppm for 12-hr samples. Reporting limit varied depending on volume of air sampled.

lost = Sample lost due to sampler malfunction or laboratory error.

Table 5. Analysis of variance table for two factor design using maximum 24 hour TWA concentration for each plot as variable. Tarping factor consisted of VIF versus high barrier. Edge treatment consisted of additional edge panel (no methyl bromide injected underneath) versus no additional panel around edge of treated area. Significant differences occur with tail probabilities less than 0.05. No treatments were significant.

Source	Sum of Squares*	D.F.	Mean Square*	F	Tail Probability
Mean	28096.35243	1	28096.35243	167.57	0.0002
Tarp	37.06604	1	37.06604	0.22	0.6627
Edge-Treatment	0.23120	1	0.23120	0.00	0.9722
Tarp x Edge-Treatment	137.78001	1	137.78001	0.82	0.4159
Error	670.69044	4	167.67261		

*Sums of squares based on concentration represented in parts per billion. To obtain sums of squares for parts per million, multiply values in these two columns by 10^{-6}. For example, mean sums of squares for parts per million is 0.028096. F values and tail probabilities are not affected by this transformation.

Table 6. Mean values for treatments in parts per million.

Mean Values

Tarpaulin	High Barrier	High Barrier	VIF	VIF	
Edge-Treatment	No Edges	Edges	No Edges	Edges	Total
24 hr Concentration	0.061	0.053	0.057	0.065	0.059
Count	2	2	2	2	8

Mean Values

Main Factors	High barrier	VIF	Edges	No Edges
24 hr Concentration	0.057	0.061	0.059	0.059
Count	4	4	4	4